Epitomes

Important Advances in Clinical Medicine

Nuclear Medicine

David K. Shelton Jr, MD, Section Editor

The Council on Scientific Affairs of the California Medical Association presents the following epitomes of progress in nuclear medicine. Each item, in the judgment of a panel of knowledgeable physicians, has recently become reasonably firmly established, both as to scientific fact and clinical importance. The items are presented in simple epitome, and an authoritative reference, both to the item itself and to the subject as a whole, is generally given for those who may be unfamiliar with a particular item. The purpose is to assist busy practitioners, students, researchers, and scholars to stay abreast of progress in medicine, whether in their own field of special interest or another.

The epitomes included here were selected by the Advisory Panel to the Section on Nuclear Medicine of the California Medical Association, and the summaries were prepared under the direction of David K. Shelton Jr, MD, and the panel.

Radiation Synovectomy

RADIONUCLIDE THERAPY in joint diseases offers physicians a cost-effective alternative method for treating inflammatory arthritis when standard methods of treatment such as oral anti-inflammatory drugs, intra-articular steroids, sclerosing agents, or surgical synovectomy fail. The most common indications for synovectomy are rheumatoid arthritis, psoriatic arthritis, calcium pyrophosphate disease, hemophiliac arthropathy, and pigmented villonodular synovitis. Much of the experience with radiation synovectomy comes from Europe, although its use in the United States is growing slowly.

Desirable radionuclides are those with beta-particle emissions capable of treating or destroying inflamed and diseased synovium. Beta particles are effective and have limited collateral effects because radiation from the beta particles travels only about 1 to 3 mm in soft tissues. Many radiocolloids have been used experimentally for synovectomy, including yttrium Y 90, chromic phosphate P 32, dysprosium Dy 165, holmium Ho 166, and rhenium Re 186. ^{32}P-Chromic phosphate is the only radiopharmaceutical agent in the United States approved by the Food and Drug Administration for radiation synovectomy, although ^{90}Y has been used extensively in Europe.

All major and minor joints including the interphalangeal joints can be treated with synovectomy, although the knee is most commonly treated. The technique is straightforward and safe. The knee is fully extended, prepared with povidone-iodine solution, and then the site of administration is anesthetized with a solution of 1% lidocaine. An 18-gauge needle is inserted medial to the patella, the joint space is entered, and fluid easily withdrawn. Technetium Tc 99m sulfur colloid (1 mCi, 37 MBq) is administered, and images are obtained to show the distribution of activity throughout the joint space. A common cause of treatment failure is the presence of adhesions or loculations preventing the spread of the tracer throughout the joint. ^{32}P-Chromic phosphate (6 mCi, 222 MBq) is administered to the knee joint, followed by the administration of 20 mg of triamcinolone as the needle is slowly removed. The knee is extended and flexed several times to distribute the agent throughout the joint space. The patient is placed in a knee immobilizer and instructed to restrict activity for 48 hours to lessen the risk of leakage into the soft tissues and lymphatic system.

Satisfactory results with resultant clinical improvement have been reported in 78% to 84% of patients having radiation synovectomy. This procedure with the use of ^{32}P-chromic phosphate is safe, has relatively low radiation exposure, and is efficacious in the management of patients with inflammatory arthritis not responsive to the usual treatment modalities. No serious side effects have been found as much as ten years after treatment.

ERNO J. GYETVAI, MD
CHARLES W. SUTTER, MD
Sacramento, California

REFERENCES

Harbert JC: Radionuclide therapy in joint diseases, *In* Harbert JC, Eckelman WC, Neumann RD (Eds): Nuclear Medicine Diagnosis and Therapy. New York, NY, Thieme Medical Publ, 1996, pp 1093–1109

Siegel HJ, Luck JV Jr, Siegel ME, Quines C, Anderson E: Hemarthrosis and synovitis associated with hemophilia: Clinical use of ^{32}P chromic phosphate synoviorthesis for treatment. Radiology 1994; 190:257–261

Siegel BA: Radiation synovectomy revisited. Eur J Nucl Med 1993; 20:113–127

Radiodosimetry in Nuclear Medicine

MANY OF THE EXAMINATIONS in nuclear medicine compare favorably with other diagnostic examination modalities in radiology with regard to patient dose. Several examples of diagnostic examinations in nuclear medicine provide information similar to that obtained by conventional radiography or fluoroscopy at substantially lower doses.

Just as not all radiation is equally damaging after a given absorbed dose, not all tissues are equally radiosensitive to its effects. Laboratory and epidemiologic investigations have shown that some tissues (for example, bone marrow) are at greater risk of radiogenic cancer and other stochastic effects after a given equivalent dose than other tissues (such as bladder). Tissue-specific organ-weighting factors (w_T) have been established to assign a particular organ or tissue (T) the portion of the stochastic risks resulting from the irradiation of that tissue compared with uniform whole-body irradiation. Tissue-weighting factor values range from 0.01 (for example, for skin) to 0.2 (for gonads), and the sum of all w_T equals one. The sum of the products of the equivalent dose to the organ or tissue (H_T) and the tissue-weighting factor (w_T) for each organ or tissue irradiated is called the "effective dose" (H_E)—that is, H_E (Sv) = Σ $w_T \times H_T$ (Sv). The effective dose is expressed in the same units as the equivalent dose (sievert or rem).

The effective dose provides a means to compare the risk or possible detriment between various x-ray and nuclear medicine examinations. While the procedures compared here do not provide exactly the same diagnostic information, the advantages with regard to patient dose from some nuclear medicine examinations are evident. For example, a radionuclide gastroesophageal reflux examination using 300 μCi of technetium Tc 99m sulfur colloid results in an H_E of about 0.3 mSv (0.03 rem) compared with an upper gastrointestinal examination with an H_E of about 2.4 mSv (0.24 rem). Some nuclear medicine tests not only result in a lower patient dose, but also have a diagnostic advantage relative to their radiographic counterpart. For example, radionuclide cystography is more sensitive for vesicoureteral reflux than contrast cystography and (for young women) results in an ovarian dose more than 50 times lower. These advantages of the nuclear medicine examinations are obtained at approximately the same cost as their x-ray counterpart.

In addition to minimizing patient dose, some nuclear medicine examinations have the following advantages: providing whole-body surveys that would otherwise require multiple computed tomographic scans or plain film radiographs (for example, tumor imaging with gallium citrate Ga 67 and skeletal imaging with technetium Tc 99m medronate), providing functional as well as anatomic information (for example, renal imaging with technetium Tc 99m mertiatide), and providing organ or tissue perfusion information (for example, cardiac perfusion with technetium Tc 99m sestamibi).

When diagnostic x-ray examinations require extended periods of fluoroscopy and cine radiography, alternative nuclear medicine procedures can provide lower dose alternatives. Examples include pulmonary arteriograms versus radionuclide ventilation-perfusion imaging and coronary arteriograms or ventriculography versus radionuclide cardiac perfusion or wall-motion studies. In these examples, not only is there an advantage to the nuclear medicine examinations with respect to H_E, but they also avoid the morbidity and mortality (albeit infrequent) associated with these invasive procedures, and are substaintially less expensive.

JERROLD T. BUSHBERG, PhD, DABMP
Sacramento, California

REFERENCES

Bushberg JT, Seibert JA, Leidholdt EM, Boone JM: The essential physics of medical imaging, chap 19, Radiation Dosimetry. Baltimore, Md, Williams & Wilkins, 1994, pp 633–653

Exposure of the Population From Diagnostic Medical Radiation, Report 100. Bethesda, Md, National Council on Radiation Protection and Measurements, 1989

United Nations Scientific Committee on the Effects of Atomic Radiation: UNSCEAR 1993 Report to the General Assembly, with Scientific Annexes—Sources and Effects of Ionizing Radiation. United Nations publication No. E.94.IX.2, 1993

Scintimammography—A New Tool for Breast Cancer Diagnosis

BREAST CANCER is the second most frequently diagnosed malignant neoplasm among North American women, and its incidence is increasing at a rate of 3% per year. The high morbidity and mortality warrant an aggressive approach to the diagnosis and treatment of carcinoma of the breast. Three methods are currently used for breast cancer screening: breast self-examination, breast examination by a physician, and mammography; together they have a sensitivity of 85%. Mammography has a positive predictive value of only 15% to 30%. Abnormalities identified by screening must be evaluated for malignancy by breast biopsy, with its associated physical, psychological, and economic sequelae. A number of techniques, including ultrasonography, computed tomography, magnetic resonance imaging, positron-emission tomography, and scintimammography (SMM), are currently being evaluated as non-invasive means of characterizing breast abnormalities.

The technique of prone dependent-breast SMM is being used to characterize mammographic or clinical findings. Patients receive technetium Tc 99m sestamibi (a cationic lipophilic radiopharmaceutical routinely used in myocardial perfusion imaging) intravenously, and lateral images are acquired with the patient in the prone position and with the breast dependent from the imaging table. In 153 lesions for which breast biopsy was warranted, the sensitivity of SMM was 92%, specificity was 89%, the positive predictive value was 81%, and most important, the negative predictive value for the detection of carcinoma of the breast was 96%. The uptake of ^{99m}Tc-sestamibi has been shown to be generally independent of dense breast tissue found on mammography. Preliminary results of a multicenter trial of 673 patients in the United States and Canada show that sensitivity was 85%, specificity was 81%, the positive predictive value was 74%, and the negative predictive value was 90%.

Scintimammography has high sensitivity and improves the specificity of conventional mammography for the detection of carcinoma of the breast. It is currently being evaluated as a technique to possibly reduce the number of biopsies of the breast that yield negative results for